REMARKS

By this Amendment, Tables 3 and 4 are revised and arguments are set forth below in support of the patentability of the claims. Currently, claims 1-8 are before the Examiner for consideration on their merits.

In review, claims 1-8 are rejected under 35 U.S.C § 103(a) based on either JP 61183452 to Sumitomo Metals (Sumitomo) or JP 2001107196 to Hirata et al. (Hirata). In making this rejection, the Examiner alleges that each of Sumitomo and Hirata teach a composition that overlaps that which is claimed, and therefore, these references establish a *prima facie* case of obviousness. The Examiner also takes the position that the presence of the formula does not patentably distinguish the composition given that the prior art already suggests that which is claimed.

Claims 1, 2, 5, and 6 are also rejected under 35 U.S.C § 103(a) based on JP 01287249 to Nippon. The Examiner rejects these claims for the same reasons set forth above for claims 1-8 and Hirata and Sumitomo.

Applicants respectfully traverse the rejection on the grounds that either the cited prior art fails to establish a *prima facie* case of obviousness against the rejected claims, or that the comparative evidence set forth in the specification regarding the criticality of the various alloying elements and ranges rebuts any and all contentions of obviousness. The rejections are addressed by the heading of invention and the specific prior art documents.

INVENTION

The objective of the present invention is to provide an austenitic stainless steel in which the creep strength and creep rupture ductility are improved, and the hot workability, particularly the high temperature ductility at 1200 °C or higher, is significantly improved, see page 3, lines 20-23 of the specification.

These aims have been accomplished based on the following findings:

(a) In order to increase the creep strength, it is effective to use an austenitic stainless steel, in which Cu, Nb and N are added together, for the base material.

(b) For a significant improvement of the creep rupture ductility and hot workability, particularly the high temperature ductility at 1200 °C or higher, it is effective to control P and O properly, in accordance with the Cu content.

(c) It is effective to control the Al content, in accordance with the N content, for the improvement of creep strength.

(d) Addition of V to the steel is effective in not only the improvement of creep strength but also in the improvement of toughness, after the steel is used at a high temperature, particularly at 800 °C or higher, for long period.

In order to attain the properties of (i) an excellent creep strength, (ii) an excellent creep rupture ductility, (iii) an excellent hot workability, particularly the high temperature ductility at 1200 °C or higher, and (iv) an excellent toughness after the steel is used at a high temperature, particularly at 800 °C or higher, it is very important to adjust the chemical composition of an austenitic stainless steel. To meet the properties listed above, the following conditions must be met.

A) Cu: more than 2 % to 6 %;

B) Nb: 0.1 % to 0.8 %;

C) V: 0.02 % to 1.5 %;

D) N: more than 0.05 % to 0.3 %;

E) P: 0.04 % or less and further 1/(11 x Cu) or less;

F) Sol. Al: 0.001 % to 0.1 % and further 0.4 x N or less;

G) O: 0.006 % or less;

First, Cu (Copper) is one of the most important and distinctive elements because it precipitates coherently with the austenite matrix as Cu-phase, during the use at high temperatures, and it significantly enhances creep strength of the steel. In order to exert the effects, a Cu content of more than 2 % is necessary. However, if Cu content exceeds 6 %, not only the enhancement effect of its creep strength saturates but also the creep rupture ductility and hot workability of the steel decrease. See page 9, lines 2-8 of the specification.

Second, Nb (Niobium) is an important element, similar to Cu and N. Nb forms fine carbonitride such as NbCrN, and enhances creep rupture strength and also suppresses grain-coarsening during the solution heat treatment after the final working. Thereby Nb contributes to the improvement of creep rupture ductility. However, if the Nb content is less than 0.1 %, sufficient effects cannot be obtained. On the other hand, when the Nb content exceeds 0.8 %, in addition to the deterioration of weldability and mechanical properties due to an increase in the unsolved nitride, hot workability, and also particularly high temperature ductility at 1200 °C or higher, is remarkably decreased. See page 9, lines 11-19 of the specification.

Third, V (Vanadium) forms carbonitrides such as (Nb,V)CrN, V(C,N), and is known as an effective alloying element for enhancing high temperature strength and creep strength. However, according to the present invention, V is added for enhancing the high temperature strength and toughness during long periods of use at high temperatures, particularly at 800 °C or higher. In the steel containing Cu, according to this invention, the high temperature and toughness enhancement effects of V is based on the fact that V contributes to the promotion of precipitation of fine Cu-phase, the suppression of grain coarsening and the suppression of coarsening of $M_{23}C_6$, on grain boundaries. Further V precipitates as V(C,N) thereby increases the rate of grain boundary decoration by precipitates. However, if V content is less than 0.02 %, the above-mentioned effects cannot be obtained, and if the V content exceeds 1.5 %, the high temperature corrosion resistance, ductility and toughness are deteriorated due to precipitation of a brittle phase. See page 9, line 22 to page 10, line 10 of the specification.

Fourth, N (Nitrogen) is an effective alloying element, which ensures the stability of austenite in place of a part of expensive Ni. It is also effective in contributing to enhance tensile strength because it contributes to solid-solution strengthening as an interstitial solid solution element. Also N is an element, which forms fine nitrides such as NbCrN and these nitrides enhance creep strength and creep rupture ductility by suppressing grain coarsening. Therefore, N is one of the indispensable and most important elements similar to Cu and Nb. N content of more than 0.05 % is necessary in order to exert these positive effects. However, even if the N content exceeds 0.3 %, unsolved nitride increases and a large amount of nitride increases during use at high temperatures. Accordingly, ductility, toughness and weldability are impaired. See page 11, lines 5-15 of the specification.

Fifth, P (Phosphorus) is an impurity which is inevitably contained in the steel and remarkably decreases the hot workability. Thus, the P content is limited to 0.04 % or less. Since P decreases creep rupture ductility, particularly the high temperature ductility at 1200 °C or higher, and the hot workability, due to an interaction with Cu, it is necessary that the P content should be in a range satisfying the formula $P \leq 1\ (11 \times Cu)$ as recited in the specification, see page 7, lines 7-13.

Sixth, sol. Al (acid soluble Aluminum) is an element added as a deoxidizer in molten steel. It is important that its content must be severely controlled in accordance with the N content in the steel of the present invention. Sol. Al content of 0.001 % or more is necessary in order to obtain the effects. However, if the sol. Al content exceeds 0.1 %, the precipitation of intermetallic compounds such as the σ phase is promoted during the use at high temperatures and thereby decreasing toughness, ductility and high temperature strength. Further, content of sol. Al must be controlled so as to satisfy the formula sol. $Al \leq 0.4 \times N$ in accordance with the N content. Satisfying the formula (2) prevents N from being consumed uselessly as AlN, which does not contribute to high temperature strength, and, thereby, sufficient amount of precipitation of complex nitride with Cr, (Nb,V)CrN, which is effective in enhancement of high temperature strength, can be obtained. See page 10, lines 13 to 19 and line 24 to page 11, line 3 of the specification.

Finally, O (Oxygen) is an element, which is incidentally contained in steel, and remarkably decreases hot workability. Particularly, in the steel containing Cu according to the present invention, creep rupture ductility and hot workability, especially high temperature ductility at 1200 °C or higher, are further decreased by mutual action of O and Cu. Thus, it is important to severely control the O content. Accordingly, it is necessary to

limit the O content to 0.006 % or less. Further, it is preferable that the content of O satisfies the formula O $\leq$ 1 (60×Cu) in relation to the Cu content. See page 11, lines 19 to 24 of the specification.

As will be described, Tables 1-4 as detailed on pages 20, 21, 24, and 25 of the specification, show that the claimed alloy composition formulas are critical in obtaining the properties (i-iv) as listed above.

<u>JP 61183452 TO SUMITOMO METALS (SUMITOMO) CLAIMS 1-8</u>

Sumitomo's objective is to provide a new steel having superior resistance to corrosion at high temperatures under stuck $CaSO_4$ and usable as a material for a steel pipe and/or a support for the high temperature part of a fluidized bed boiler, see page 2 lines 16-19. In order to meet these aims, the steel must have a composition including 2.0 % to 7.0% Mn. In addition, Sumitomo desires to have Cu, Al, and V in order to increase the strength of the steel, see page 4, lines 8-10.

It is respectfully contended that Sumitomo does not provide the motivation to arrive at the composition of claims 1-4. In review, claim 1 calls for the critical components as set forth in items A-G above, including the formulas regarding phosphorous and sol. Al. More particularly, the invention has critical amounts of Cu, together with N and Nb in order to enhance creep strength. In addition, V is added in order to enhance not only the high temperature strength but also toughness during the long period of use at high temperatures, particularly at 800 °C or higher. Al, especially sol. Al is added in accordance with the stated formula and in order to obtain the deoxidation effect, the excellent toughness, the excellent ductility, and the excellent high

temperature strength. For these reasons, Sumitomo, in spite of any remote overlap with the various elements of the claims, is not concerned with the problems faced by the inventors and does not render claim 1 obvious under 35 U.S.C § 103(a). In particular, there is no basis for the Examiner to conclude that the formulas have no effect on the composition, and to the contrary, the specification shows that they do, and the rejection must be withdrawn for failing to suggest the formula.

While it is contended that Sumitomo does not establish a *prima facie* case of obviousness against claim 1 on the basis that one of skill in the art could not derive the various ranges for Cu, Nb, V, N, P, sol. Al, and O, Applicants contend that any allegation of obviousness is effectively rebutted by the comparison set forth in the specification.

Phosphorous

Referring again to Tables 1-4, the Examiner's attention is directed to comparative steels A-C and Steels 1 and 2 of the invention. Comparative steels A-C are designed to show the criticality of the phosphorous content of the invention. Steels A-C have phosphorous contents that fall outside the range of the formula (1) recited in claim 1. The chemical compositions, except for P, of the comparative steels A and B are the same as those of steels 1 and 2 of the present invention. The P content of comparative steel C is substantially the same as that of the steel 2 of the present invention. It should also be noted that the phosphorous content of comparative steels A-C falls within the range suggested by Sumitomo. Turning to Table 4, the comparison of A-C to steels 1 and 2 shows that steels A-C have poor creep rupture reduction in area and creep rupture elongation. This means that the creep rupture ductility and hot workability for these alloys is poor. In contrast, alloys 1 and 2 that have phosphorous levels meeting

the requirements of the formula of claim 1, have vastly superior creep rupture reduction in area and creep rupture elongation values. This improvement through control of phosphorous in light of copper is totally unexpected and evidences that controlling the phosphorous levels to achieve these results would not be an obvious modification of Sumitomo.

Sol. Al

In a similar vein, comparative steels D-F exhibit significantly reduced creep rupture strength in Table 4 when compared with the inventive alloys. At most, these alloys show a value of 68.4, whereas the alloys meeting the requirements of claim 1 are significantly higher.

Vanadium

The criticality of the control of V is also demonstrated in the Tables of the specification. Comparative alloys G, H, I do not exhibit a vanadium content within the limits of claim 1, but these alloys still fall within the ranges set by Sumitomo, i.e., less than 3.0%. With little or no vanadium, the creep rupture strength values are far less than that shown for the alloys of the invention. Moreover, alloys G and H also exhibit poor charpy impact values, further demonstrating the criticality of the levels of vanadium as specified by claim 1.

Copper

Comparative alloys J and K lack the requisite copper required by claim 1, and as a result, Table 4 shows poor creep rupture strength as compared to the alloys following the invention.

Nitrogen

Comparative alloy L has a nitrogen content within the range of Sumitomo, but outside the range of claim 1. Alloy L has inferior creep rupture strength, see Table 4, when compared with the inventive alloys, and this comparison shows that nitrogen below the limit of 0.3% results in favorable creep rupture properties.

Prima facie case of obviousness is rebutted

While the Examiner contends that Sumitomo establishes obviousness, the comparison in the specification demonstrates that the various levels of alloying elements and formula are critical to the alloy performance, and that the values are not merely obvious variants of Sumitomo. Each of P, sol. Al, V, Cu, and N have been shown to be important in producing the properties listed above as (i-iv). Even with the suggestions of Sumitomo, one of skill in the art could not arrive at the invention of claim 1 for the reason that the results in terms of creep rupture properties are quite unexpected. Thus, the rejection of claim 1 based on Sumitomo must be withdrawn in light of this evidence.

Again, the Examiner's reliance on In re Cooper to dismiss the formula as having patentable significance is noted. However, the comparative evidence has shown that for the formulas involving P and sol. Al, critical results are attained if the composition falls within the formula whereas for a similar composition, results are not obtained if the formula is not met. Therefore, the formula does have significance in terms of the alloy composition, and it cannot be summarily dismissed merely because Sumitomo may suggest a composition that has overlapping ranges.

Claims 2-4

Since each of claims 2-4 contains the features of claim 1, and claim 1 is patentably distinguishable from Sumitomo, claims 2-4 are also in condition for allowance. The remaining claims 5-8 are allowable by reason of their dependency on claims 1-4.

JP 2001107196 TO HIRATA ET AL. (HIRATA) CLAIMS 1-8

The Examiner takes the same position regarding Hirata as was explained above for Sumitomo, i.e., Hirata establishes a *prima facie* case of obviousness based on an overlapping composition. This rejection is traversed for the same reasons that Sumitomo is traversed. That is, any *prima facie* case of obviousness is rebutted by the discovery that the claimed composition provides an alloy that has excellent creep rupture strength, creep rupture elongation, and creep rupture reduction in area, characteristics not collectively found in any comparative steels A-L.

Hirata is directed to a weld metal composition that is designed to have weld cracking resistance and good corrosion resistance in sulfuric acid environments. Hirata accomplishes these aims through close control of Cu and V. In contrast, the present invention uses Nb and N with Cu to enhance creep strength and high temperature strength, aims completely different than the aims of Hirata. One of skill in the art would not be taught to control the elements of Cu, Nb, and N in the manner set forth in claim 1 based on the teachings of Hirata. Thus, this reference does not even establish a *prima facie* case of obviousness.

Hirata does suggest that one or more of Nb, Ta, Ti, and Zr are added in amounts of 0.1-5% together with N in an amount of 0.1% or less. The addition of Nb, Ta, Ti, and Zr is intended to fix C as a carbide and to complicate the grain boundary structure for

weld crack resistance. N is added to form nitrides for strength. In contrast, the invention uses Nb and N with Cu to obtain excellent creep rupture strength and creep rupture ductility, and one of skill in the art would not be led to this discovery through the mere overlap of ranges of Hirata with the present invention.

Finally, Hirata suggests a limit of Al of 0.5% or less for a deoxidation effect. According to the invention, sol. Al is controlled for not only deoxidation, but also toughness, ductility and high temperature strength, and one would not be taught to arrive at the claimed range of 0.001% to 0.1% sol. Al or the claimed formula with just the teachings of Hirata.

To conclude that Hirata establishes a *prima facie* case of obviousness is the application of hindsight, and this taints the rejection so as to make it untenable.

Therefore, the rejection of claim 1 based on Hirata fails for two reasons, one being that Hirata fails to establish obviousness, and even if it does, the demonstration in the specification effectively rebuts any allegation of obviousness. Claims 2-4 and 5-8 are also patentable for the same reasons set forth above under the discussion of Sumitomo.

JP 01287249 TO NIPPON CLAIMS 1, 2, 5, AND 6

It is respectfully submitted that Nippon either fails to establish a *prima facie* case of obviousness or any such case is effectively rebutted by the evidence set forth in the instant specification.

The objective of Nippon is to provide an austenitic steel tube having excellent steam oxidizing resistance and high temperature strength and a method of making such

a steel. To reach this goal, Nippon controls N to 0.5% or less, and utilizes Cu and V as well, see page 4, line 1.

However, claim 1 requires more that 2% and to 6% Cu with more than 0.05% to 0.3% N together with 0.1 to 0.8% Nb to enhance creep strength, and there just is no reason why one of skill in the art would arrive at these ranges in Nippon.

Claim 1 is further distinguishable on the grounds of the presence of sol. Al and P and their respective formulas. In Nippon, Al is added for deoxidation purposes but there is no recognition of its capability to provide excellent toughness, ductility, and high temperature strength as is accomplished via the limits of sol. Al and its formula.

Even, *assuming arguendo,* that Nippon establishes a *prima facie* case of obviousness against claim 1, it is respectfully contended that such a case is rebutted by the evidence as detailed in the traversal of the rejection based on Sumitomo. Consequently, the rejection of claim 1 based on Nippon should be withdrawn.

SPECIFICATION CHANGES

The heading regarding the amount of precipitates in Tables 3 and 4 has been changed by submission of the corrected Tables. The precipitates originally shown as (Nb,V) CrN in the second column should read V(C,N). No new matter is introduced by this amendment, since the specification on page 9, the fourth last line describes the types of vanadium compounds formed by the invention.

SUMMARY

By the arguments set forth above, it is respectfully submitted that the applied prior art either fails to establish a *prima facie* case of obviousness against the pending claims or that the comparative evidence set forth in the specification rebuts any and all allegations of obviousness, thus making claims 1-4 and their dependent claims patentable over Sumitomo, Hirata and Nippon.

Accordingly, the Examiner is respectfully requested to examine this application in light of this amendment and pass all pending claims onto issuance.

If the Examiner handling this application believes that an interview would help expedite allowance of this application, the Examiner is invited to telephone the undersigned at 202-835-1753.

The above constitutes a complete response to all issues raised in the Office Action dated September 17, 2004. Again, reconsideration and allowance of this application is respectfully solicited.

Please charge any fee deficiency or credit any overpayment to Deposit Account No. 50-1088.

Respectfully submitted,
CLARK & BRODY

Christopher W. Brody
Registration No. 33,613

Customer No. 22902
1750 K Street NW, Suite 600
Washington DC 20006
Telephone: 202-835-1111
Facsimile: 202-835-1755
Docket No.: 12049-0016
Date: December 15, 2004

Table 3

	Steel No.	Amount of Precipitates (Nb,V) CrN (Number/μm^2)	Amount of Precipitates V (C,N) (Number/μm^2)	Reduction of Area (%)	Creep Rupture Strength (MPa)	Creep Rupture Elongation (%)	Charpy Impact Value (J/cm^2)
Steel of This Invention	1	9	21	88.1	71.2	31.9	-
	2	10	24	70.4	71.0	27.1	-
	3	13	48	90.1	73.1	33.6	-
	4	12	51	78.0	73.6	31.1	-
	5	6	25	82.5	75.1	30.9	-
	6	6	28	88.3	75.8	32.2	-
	7	9	22	85.2	70.2	34.0	88
	8	15	162	83.5	78.5	29.1	105
	9	9	71	95.1	79.5	31.9	-
	10	12	95	89.8	80.5	32.2	-
	11	14	108	93.2	80.2	35.3	-
	12	9	42	72.0	70.9	27.3	-
	13	12	56	84.9	80.4	32.9	-
	14	12	74	81.6	80.5	31.0	-
	15	10	48	79.5	81.1	26.8	-
	16	13	76	83.7	80.0	30.4	-
	17	12	60	80.7	79.8	28.4	-
	18	15	82	79.2	79.7	31.2	-
	19	13	102	92.1	75.1	24.7	-
	20	13	66	93.0	75.4	30.2	-
	21	21	268	90.8	78.8	27.7	-
	22	14	87	95.2	74.6	29.5	-
	23	13	74	90.1	74.9	31.8	-
	24	14	94	93.6	75.0	33.8	-
	25	14	80	92.6	75.1	29.1	-
	26	12	88	88.5	79.8	30.7	-
	27	9	44	78.1	80.2	26.9	

Table 4

	Steel No.	Amount of Precipitates (Nb,V) CrN (Number/μm^2)	Amount of Precipitates V (C,N) (Number/μm^2)	Reduction of Area (%)	Creep Rupture Strength (MPa)	Creep Rupture Elongation (%)	Charpy Impact Value (J/cm^2)
Steel of This Invention	28	7	17	75.5	80.5	27.0	-
	29	8	12	76.4	81.2	30.3	-
	30	7	23	78.4	81.4	27.8	-
	31	8	14	77.2	80.5	28.6	-
	32	8	13	76.5	80.8	29.0	-
	33	11	51	84.1	80.1	31.7	-
	34	11	53	92.0	80.4	31.7	-
	35	12	61	93.5	80.2	29.6	-
	36	10	56	92.6	80.9	28.1	-
	37	12	68	84.9	80.4	31.3	-
	38	9	54	81.6	72.5	30.0	-
Comparative Examples	A	11	34	55.6	71.4	9.0	-
	B	10	28	32.3	70.9	5.5	-
	C	10	29	51.3	72.5	7.0	-
	D	7	35	88.7	68.4	32.8	-
	E	7	25	90.9	66.2	32.0	-
	F	6	22	91.2	67.5	31.9	-
	G	4	3	86.6	63.1	30.4	51
	H	3	2	84.8	61.7	31.4	40
	I	3	2	94.2	62.8	35.5	-
	J	12	85	91.0	68.0	32.3	-
	K	10	51	91.1	69.8	36.0	-
	L	3	5	75.7	66.8	25.9	-